

*D. Hughes Bennett
with the Author's Kind Regards*

ON THE



PATHOLOGY OF TETANUS,

ILLUSTRATED BY CASES AND DRAWINGS.

BY

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COMMUNICATED BY

DR. RADCLIFFE.

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NOTWITHSTANDING the number of cases of tetanus in which the spinal cords have been dissected and carefully examined in the ordinary way, by different persons in different countries, no observer, I believe, has hitherto discovered anything like definite lesions, or anything, indeed, abnormal, except a general increase of vascularity or a variable and local congestion. Up to the present time, therefore, the *pathology* of this frightful malady has been involved in the greatest obscurity, and various are the speculations in which theorists have indulged, in the absence of positive knowledge, to explain its mysterious nature. In this communication, however, I shall show, beyond the possibility of doubt, that in six cases in which the cords were examined by myself, lesions of structure of different kinds, and frequently of surprising extent, were discovered.

The first case which I shall bring before the attention of this Society occurred in the North Staffordshire Infirmary. Its history, which was furnished me by Mr. W. Dunnctt Spanton, is as follows :

“Joseph G—, æt. 46, single, a labourer, was admitted into the North Staffordshire Infirmary, October 22nd, 1864, for extensive burns.

“The patient, a strong, muscular, healthy man, had, while intoxicated, been sleeping near a lime kiln, and his clothes caught fire, causing deep burns of the face, arms, neck and chest. He was brought to the infirmary about six hours after the accident.

“On admission the burnt surface was dressed with a strong solution of nitrate of silver and cotton wool ; he was ordered to take an effervescing mixture with ten drops of tincture of belladonna every four hours, and to have milk, beef tea, and four ounces of wine.

“On October 28th delirium came on, the patient being very weak ; the burns sloughing. Some carbonate of ammonia was ordered, and the belladonna omitted. An opiate was given at night.

“The man became weaker, the delirium continuing more or less up to the early morning of November 1st (ten days after admission), when trismus became marked. The patient complained first of some pain and aching about the muscles of the jaws and neck, and then experienced some difficulty in opening his mouth, which, in the course of about two hours, was so much increased that a spoon could not be put between the teeth. When fluid was poured between his teeth the patient had some difficulty in swallowing it. The delirium completely left him, and he appeared quite intelligent, replying to questions as well as his altered voice would permit.

At 10 a.m. of the same day, when an attempt was made to sit up in bed, opisthotonos came on, which quite prevented his doing so. Trismus was almost complete ; there was no spasm of the extremities. Risus sardonicus was present in

some degree; skin was hot and dry; pupils equal, of moderate size, acting freely to light; pulse 130, full, soft; respiration 25, spasmodic, short; bowels acted the day previously; micturition free.

"Was ordered to take two minims of Fleming's tincture of aconite in a very small quantity of water every hour, the dose to be rapidly increased, and to have enemata of milk and brandy every four hours.

"2 p.m.—Risus sardonicus more marked; intelligence clear; trismus complete; the patient says that since he took the medicine the pain about the jaws has almost gone; opisthotonos when any attempt is made to move, but not constant; able to swallow a few drops at a time when poured between the teeth; no spasm of the extremities; pulse 130, soft, smaller; respiration 26, short, and irregular; passes water with difficulty.

"During the evening spasm of the limbs came on, with marked opisthotonos, the patient evidently becoming weaker. The dose of tincture of aconite was increased up to twelve drops, but was not taken so regularly as at first. The patient died at midnight, apparently from exhaustion, being quiet for a short time before death.

"A post-mortem examination was made twelve hours after death.

"Body warm; rigor mortis slight; over the face, neck, both arms, the anterior and right side of the chest, were the marks of a deep burn, the surface suppurating. Body well nourished; subcutaneous fat in moderate amount.

"The cellular tissue and muscles of the back, especially in the upper dorsal region, were deeply congested; there was no ecchymosis. On opening the spinal canal the membranes of the cord at the upper cervical region presented a redder appearance than elsewhere, and the vessels were more congested. The cut surface of the spinal cord, at the junction of the cord with the medulla, was of a pink colour. The cord was removed entire, and sent to Mr. Lockhart Clarke for examination.

"The brain was quite healthy in appearance, and firm.

There was a small quantity of clean serum in each lateral ventricle. The membranes were of a natural colour.

"The chest and abdomen were not examined."

Morbid anatomy.—The parts which were sent by Mr. Dunnett Spanton for my examination were preserved in a weak solution of chromic acid.

The medulla oblongata and the upper end of the cord which gives origin to the first cervical nerves were apparently free from disease. At the second cervical nerves, however, streaks and irregular areas of disintegration were observed in different parts of the gray substance, and particularly around the central canal, on the right side of which was a space of considerable size, containing a finely granular fluid, with the debris of blood-vessels and nerves. The posterior and lateral white columns, especially along the edges of the various fissures which transmit blood-vessels, were damaged in a similar way; and in some sections the deeper portions of the posterior columns which rest on the transverse commissure were softened to a considerable degree.

On descending through the cervical enlargement the lesions of structure in the gray substance continued to increase, and occurred chiefly behind and at the sides of the canal. In fig. 1, Plate IV, the posterior commissure between the bases of the horns was destroyed by a fluid, transparent and granular area (*a*), containing the debris of the tissue which it replaced, and bounded by the jagged or irregular edges of the adjacent tissue, which projected into it to different distances, and were readily observed to be themselves in process of disintegration. On the left of this transparent space, at the base of the posterior horn, the solution was only partial, for the softened substance was either infiltrated uniformly by fluid or eroded, as it were, irregularly by small but numerous points of fluidity. Close on the right and in front of the canal, amongst the decussating fibres of the anterior commissure, was another fluid space of considerable size, transparent, indeed, but granular from the debris of the fibres which it replaced.

In fig. 2 the posterior commissure behind the canal



Fig 1.



Fig 2

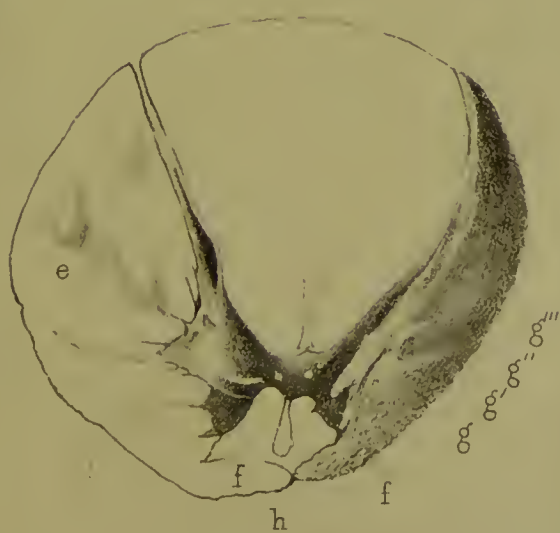


Fig 3.



Fig 4

was completely destroyed by two semifluid and irregular areas (*a, a*), which coalesced at different points, and on the left side one of these was continuous with a large and perfectly fluid space (*b*), which extended from behind forwards, quite across the gray substance, dividing the anterior commissure, and containing the remains of an eroded blood-vessel (*c*) which entered through the anterior fissure. On the right side the anterior commissure was further damaged by two separate but fluid spaces (*b*) of smaller size.

Throughout the rest of the cervical enlargement lesions were discovered like those I have just described, varying from a state of softening to a state of complete solution, and diminishing at intervals, or almost disappearing, to return shortly in the same form.

At the upper part of the dorsal region the shape of the cord was much altered, and extensive lesions were everywhere seen. On the left side, as shown in fig. 3, the lateral half of the gray substance (*d*) was softened almost to fluidity, and rendered exceedingly transparent. In the lateral column (*e*) were several elongated and crescentic areas of partial disintegration, and the superficial half (*f*) of the corresponding anterior column was softened to a considerable degree. On the opposite side the lateral portions of both the anterior and posterior gray substance were destroyed by long tracks or streaks of fluid disintegration (*g g' g'' g'''*), and the remains of the posterior horn (at *g'''*) had fallen backwards and outwards with the antero-lateral column. This column was much softened, especially anteriorly, and in its deeper layers, which were reduced to a semifluid state and fused with the lateral part of the gray substance (at *g g' g''*), so that the line of demarcation between the two kinds of structure—as seen on the opposite side—was wholly obliterated. The superficial portion of the anterior column (*f'*) had a kind of spongy or quaggy consistence, in consequence of the minute areas of fluid or semifluid disintegration which existed between its bundles. At the anterior median fissure the edges of the anterior column had been destroyed by the same morbid process, which resulted in the formation of a perfectly fluid

but finely granular space of a pyriform shape.^(Z) At the posterior median fissure a somewhat similar appearance was observed, and in the posterior columns there were numerous irregular areas of partial disintegration, like those in the lateral column of the opposite side.

For the distance of a few lines the morbid appearances diminished both in extent and degree; but about half an inch lower there was some dilatation of the cord, in which the lesions were very similar to those represented in fig. 3; and just below this a considerable extravasation of blood was found in the posterior columns between the horns. At the fourth dorsal nerves the cord was again much swollen, chiefly along the posterior columns, and the gray substance was extensively damaged, as shown in fig. 4, in which the irregular blank spaces represent areas of fluid disintegration, more or less interrupted or traversed, in different ways, by masses and streaks of half-dissolved tissue. Moreover, an alteration in shape and a want of symmetry of the opposite sides were frequently observed. In fig. 4 the changes are seen chiefly on the left side, where the posterior horn is thrown outwards.

Immediately below this swelling the lesions of structure diminished considerably, although the gray substance contained many small spaces in different stages of disintegration; but after a few lines in descent the lesions again increased, and large extravasations of blood were found along the whole lateral part of the gray substance, on both sides in some sections, on one side only in others; soon, however, they entirely disappeared, and only a few small areas of disintegration remained; but after a very short interval they returned in the same form; and so, through the rest of the dorsal region, the different kinds of structural change alternating in extent and degree, sometimes existing together, sometimes singly, and at other times almost disappearing, were observed in different sections. At the lowest part of this region there was no hæmorrhage whatever, and the gray substance was less damaged than elsewhere.

It will not be necessary to describe in detail the morbid

appearances discovered in the lumbar region. It is sufficient to state that they bore a general resemblance to those found in other parts of the cord, particularly in the cervical enlargement.

The second case to which I shall call attention is one of idiopathic tetanus which occurred in St. Mary's Hospital. The notes of the history and treatment I have not yet received, but the spinal cord was sent to me for examination by Dr. Handfield Jones. For my present purpose, I need only say that areas of disintegration and exudation were discovered in different parts of the cord, but chiefly in the central gray substance.

The third case, which was of the traumatic kind, occurred in the North Staffordshire Infirmary. The spinal cord, as I received it from Mr. Dunnett Spanton, was much mutilated, and spoiled by long maceration in spirits of wine; but, notwithstanding, I was able to affirm with great confidence that in the lumbar region, at least, the posterior gray substance contained numerous streaks and irregular areas of disintegration. The case was published in the *Lancet* of June 3rd, 1865.

The fourth case, of which I have not yet received the history, died in the West Norfolk and Lynn Hospital. The spinal cord, which was sent to me by Dr. Lowe, I have only partly examined, but I have seen enough to convince me that it contains lesions of the same nature as those described in the first case.

The fifth and sixth cases occurred in St. George's Hospital. Only parts of the cords fell into my possession; but these presented the most unequivocal marks of structural lesions. Both cases were published in the '*Lancet*' of September 3rd, 1864, with illustrations, and the preparations from which the drawings were made accompany this communication.

In these six cases I have given nothing but the actual pathological facts, without any theory or speculation. But these facts suggest certain questions which are very important in a physiological and pathological, but especially in a practical, point of view.

1. Are structural lesions present in those cases of tetanus

which recover? That they are *not* present, or are present only in a small degree or to a slight extent, is probable from the actual fact of the recovery, which certainly could not take place, at least without consequent paralysis, if the lesions were as extensive as those discovered in the above cases. It is not improbable that small exudations or even minute structural changes may have occurred, and been arrested in their course, and it would be interesting to ascertain whether, in cases of recovery, any paralytic affections or abnormal phenomena of motion or sensation remain after the attack.

2. Are the structural lesions or disintegrations of tissue the *effects* of the functional excitement of the cord manifested in the tetanic spasms? That they are *not* the effects of this excitement would appear from the following facts:— That they more frequently occur in the central parts of the gray substance around the canal, where the nerve-cells are scanty; that the nerve-cells of the anterior gray substance which give origin to the motor nerve-roots remain apparently unimpaired; that the structural changes commence frequently in company with exudations around or in the vicinity of blood-vessels, which are themselves commonly found dilated, and frequently in a state of disintegration; and, lastly, that they are exactly similar in kind to the lesions or disintegrations which I find in various cases of ordinary paralysis, in which there is little or no spasmodic movement.¹ It appears, therefore, that they result from a *morbid* state of the blood-vessels, and not from excessive functional activity of the cord.

3. Are the structural lesions of the nerve-tissue the *cause* of the tetanic spasms? That they are not the direct or sole cause may be inferred from the fact that in those cases of paralysis in which similar lesions exist they do not give rise to tetanic spasms or convulsions, although twitching of individual muscles or groups of muscles is not uncommon.

4. On what, then, do the tetanic spasms really depend?

¹ See 'Beale's Archives of Medicine,' No. IX, 1861; No. XIII, vol. iv. 'British and Foreign Med.-Chirurg. Review,' Oct., 1863, and especially April, 1864, and July, 1864.

Since the lesions of the cord in cases of paralysis in which there is commonly no spasm, are similar to those of tetanus, it follows that the latter disease, in regard to its morbid anatomy, differs from the former only in being associated with a morbid condition or injury of some of the peripheral nerves. It would therefore appear that this condition or injury of the peripheral nerves is the determining cause of the phenomena, and that the spasms of tetanus depend on the conjoint operation of two separate causes. First, that they depend on an abnormally excitable state of the gray nerve-tissue of the cord, induced by the hyperæmie and morbid state of its blood-vessels, with the exudations and disintegrations resulting therefrom. This state of the cord may be either an extension of a similar state along the injured nerves from the periphery, or may result from reflex action on its blood-vessels excited by those nerves. Secondly, that the spasms depend on the persistent irritation of the peripheral nerves, by which the exalted excitability of the cord is aroused; and thus the cause which at first induced in the cord its morbid susceptibility to reflex action is the same which is subsequently the source of that irritation by which the reflex action is excited.¹

This explanation derives some confirmation from certain cases of paralysis. In one of these, which I published in the 'British and Foreign Medico-Chirurgical Review,' July, 1864, there was partial paralysis of one arm, and the lesions and disintegrations which I found in the cervical enlargement of the cord bore a very striking resemblance to those which I have described in the first case of tetanus recorded in this paper. So long as the arm was enveloped and kept warm in flannel it remained perfectly still, but whenever it was ex-

¹ In so-called idiopathic tetanus, arising from exposure to cold and damp, it is probable that the morbid condition of the blood-vessels of the cord results from changes in the state of the peripheral nerves, which may act through reflex action or otherwise. There are many facts recorded which tend to show that congestion and inflammation of the nervous centres are produced in a similar way.

posed to the impression of cold air it began to move in a spasmodic and jerking manner.

APPENDIX.

In the walls of the blood-vessels there was no morbid deposit nor any appreciable alteration of structure, except where they shared in the disintegration of the part to which they belonged; but the arteries were frequently dilated at short intervals, and in many places were seen to be surrounded, sometimes to a depth equal to double their diameter, by granular and other exudations, beyond and amongst which the nerve-tissue, to a greater or less extent, had suffered disintegration. We have reason, therefore, to infer that the lesions of structure had their origin in a morbid condition of the blood-vessels, resulting in exudations with impairment of the nutritive process.

Of the structural changes which constitute what I have called "granular" and "fluid" disintegration—whether they commence immediately around the blood-vessels or not—the first stage consists of a softening of the nerve-tissue. When a small portion of this tissue is very carefully placed on a glass slide, without further disturbance—even without covering-glass, to avoid compression—and examined under a sufficiently high magnifying power, a large number of the nerve-fibres are found to be more or less altered in structure. Their medullary sheaths, or white substance, are either ragged, puckered, wrinkled or granular; or they are partially stripped from their axis-cylinders and broken into fragments of different sizes, or formed into globular masses.¹

In the second stage the nerve-substance becomes softer or semifluid, and more transparent. A greater number of the fibres are involved in the destructive process, and the frag-

¹ See also 'British and Foreign Medico-Chirurgical Review,' April, 1864, p. 491, and fig. 5 B.

ments of those that were first destroyed are reduced to finer particles and mingle with the granules of the exuded fluid. To this morbid condition I have given the name of "granular disintegration."

By a continuation of the same process the substance becomes reduced to a perfectly fluid state. Sometimes a fluid area of considerable size originates at a single spot, which gradually increases by solution of the surrounding tissue. This is more common around the larger blood-vessels. Sometimes it begins at several isolated spots, which advance towards each other and coalesce, in various ways, between irregular masses of the tissue, which either remain connected, more or less, with the surrounding substance, or are separated and left as islets in the fluid.¹ In such cases the gradual transition from granular disintegration to a state of solution may be very readily observed along the edges of the several masses. The fluid itself, however, as might be expected, is at first more or less granular, holding in suspension the fragments and particles of the disintegrated substance; but in many places it is perfectly pellucid.

The transition from the one condition to the other may be very strikingly observed in some isolated spots where the process of solution is most rapid from without inwards. In these cases, although the fluid at the circumference may be perfectly clear, it becomes not only granular, but more coarsely granular, on approaching the centre, where the process of solution is later. These isolated spaces are very often sharply circumscribed, as if the tissue had been suddenly dissolved by a drop of some solvent fluid. They are frequently seen around or at the sides of the blood-vessels, and are commonly more or less fusiform, oval, or circular.²

¹ See also 'British and For. Medico-Chirurgical Review,' July, 1864.

² See Beale's 'Archives of Medicine,' 1861, No. IX, pl. i, fig. 3; and 1863, No. XIII, pl. ii, fig. 1.



